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A COST DIFFERENCE ANALYSIS

OF

STATE EMPLOYEE TRAVEL

DRIVING VS. FLYING

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I. SCOPE AND PURPOSE OF STUDY

The purpose of this study is four-fold:

1) to attempt to establish some general statements about whether a given travel situation is less expensive by automobile or airplane;

2) to investigate the possibility of developing look-up tables or matrices to determine the cost of travel by automobile or airplane;

3) to investigate the possibility of developing several algorithms for determining the cost of state travel by automobile or airplane;

4) to determine if further study is necessary and, if it is, what broad assumptions should be made to continue such a study.

The scope of this study has been determined by the time and resources available for investigation. Following is a list of variables and their values that were used to determine the cost of driving or flying.

VARIABLE LIST

1. Cities and towns (31) and the driving and flying distance to each in statute miles (See Appendix 1)

   Let
   DD = driving distance to City A
   DF = flying distance to City A

2. Length of scheduled meetings (in hours) in each city

   There were 6 alternative meeting lengths used - 2, 5, 8, 13, 24, and 35 hours.

   Let
   NH = meeting length in City A

3. Per diem rates depending on the meeting length and the city where the meeting is held (See Appendixes 2 and 3)

   Let
   APD = per diem rate for flying to City A for meeting of NH hours long
   DPD = per diem rate for driving to City A for meeting of NH hours long

4. Median grade level of group driving or flying to the meeting in City A

There were two grade levels chosen - 14 and 17 and the step level used was Step 4 (1976-77 salary matrix).

GRADE LEVEL	PAY RATE/HOUR
14	7.36
17	9.57

Let
CG = median pay rate for the group attending the meeting in City A

5. Number of passengers making trip

There were five levels used - 1, 2, 3, 4, and 5 passengers.

Let
NP = number of passengers making this trip to City A

6. Aircraft

Four alternative aircraft were used to compare with driving.

AIRCRAFT	SPEED	COST*
Duke	242	225
C-340	230	155
Baron 58	225	125
A-36	190	50

*Does not include cost of pilot, which is $10 per hour.

Let
APS = per hour speed of airplane used for trip to City A
APC = per hour cost of airplane used for trip to City A

7. Taxi fare when flying to City A

Taxi fares are dependent on the meeting lengths. The values for taxi fares used in this study were:

Meeting Length (hours)	2	5	8	13	24	35
Taxi Fare (dollars)	5	5	5	7	8	10

Let
TF = taxi fare in City A when we have a meeting of length = NH

8. Cost of Automobile

The cost of the automobile (state car) is dependent upon the number of passengers making the trip to City A.

Passengers	1	2	3	4	5
Cost (rate per mile) in dollars	.113	.113	.113	.113	.118

Let

RPM = rate per mile to drive a state car to City A with the number of passengers = NP

9. In-town miles driven

The number of miles driven in City A while on this trip is dependent on the length of the meetings. The values assumed for this study were:

Meeting length in hours	2	5	8	13	24	35
In-town mileage (miles)	30	30	30	40	50	60

Let

TM = in-town mileage when driving to City A for a meeting of length = NH

10. Management Accountability Factors

Management accountability factors are defined as the loss to the state while an employee is engaged in non-productive work (driving or flying). Three sets of accountability factors were used in this study, depending on the median grade level of the people making the trip.

ACCOUNTABILITY FACTORS

	- - - SET - - -		
Grade Level	1	2	3
14	1	1.37	1.75
17	1	1.75	2.5

Let

MAF = management accountability factor for this group with median grade level = CG on trip to City A

11. Constants

Some constants were assumed in order to develop cost equations. These were:

average driving speed = 45 mph
additional time spent driving on each trip = ½ hour
additional air hours for taxiing, etc. = 12 minutes
additional pilot time for readying aircraft, etc. = 1 hour and 18 minutes
additional air hours for passengers = 36 minutes

These constants were the same as those assumed in the Legislative Auditor's study. Using the variables and constants described above, one can construct cost equations for driving or flying to City A.

1. Cost of Driving to City A = CDR

$$CDR = \{ (DD + TM) \cdot RPM \} + \{ (DD \div 45 + .5) \cdot CG \cdot MAF + DPD \} \cdot NP$$

where

CDR = cost of driving to City A
DD = distance driving to City A
TM = in-town mileage
RPM = cost per mile of state car
CG = pay rate of median grade level
MAF = management accountability factor
DPD = driving per diem for meeting length
NP = number of passengers

2. Cost of Flying to City A = CFL

$$CFL = \{ APC \cdot (DF \div APS) \} + \{ (1.3 + NH + DF \div APS + .2) \cdot \$10 + APD \} + \{ (DF \div APS + .2 + .6) \cdot CG \cdot MAF \} \cdot NP + TF$$

where

DFL = cost of flying airplane 1 to City A
APC = per hour cost of airplane 1
DF = distance flying to City A
APS = average air speed for airplane 1
NH = meeting length in hours
APD = per diem rate for flying
CG = pay rate for median grade level
MAF = management accountability factor
NP = number of passengers
TF = taxi fare

II. RESULTS - GENERAL CONCLUSIONS

In order to reduce the total amount of data available for analysis, the cities were grouped into three zones depending on their distance from Helena. (See Appendix 4)

Although it is difficult to be very specific, one can generally state that for each set of management accountability factors the following is true:

A. MAF set 1 where Grade 14 = 1 and Grade 17 = 1

(i) Zone 1

Passengers	Meeting Length	Conclusions
1-2	all	seldom less expensive to fly
3-4	8 hours or less	fly (use A-36 or Baron)
5	8 hours or less	generally less expensive to fly

(ii) Zone 2

Passengers	Meeting Length	Conclusions
1	all	seldom less expensive to fly
2	8 hours or less	fly (use A-36)
3	8 hours or less	fly (use A-36 or Baron)
4-5	24 hours or less	generally less expensive to fly

(iii) Zone 3

Passengers	Meeting Length	Conclusions
1	all	seldom less expensive to fly
2	8 hours or less	fly (use A-36)
3	24 hours or less	fly (use C-340, Baron or A-36)
4-5	all	generally less expensive to fly

B. MAF set 2 where Grade 14 = 1.37 and Grade 17 = 1.75

(i) Zone 1

Passengers	Meeting Length	Conclusions
1	all	seldom less expensive to fly
2-3	8 hours or less	fly (use C-340, Baron or A-36)
4-5	24 hours or less	generally less expensive to fly

(ii) Zone 2

Passengers	Meeting Length	Conclusions
1	2 hours	fly (use A-26)
2-3	13 hours or less	fly (use C-340, Baron or A-36)
4-5	24 hours or less	generally less expensive to fly

(iii) Zone 3

Passengers	Meeting Length	Conclusions
1	8 hours or less	fly (use A-36)
2	24 hours or less	fly (use Baron or C-340)
3-5	all	generally less expensive to fly

C. MAF set 3 where Grade 14 = 1.75 and Grade 17 = 2.5

(i) Zone 1

Passengers	Meeting Length	Conclusions
1	2 hours	Grade 17 - fly (use A-36)
2	8 hours or less	fly (use C-34, Baron or A-36)
3-5	24 hours or less	generally less expensive to fly

(ii) Zone 2

Passengers	Meeting Length	Conclusions
1	8 hours or less	Grade 17 - fly (use A-36)
2	24 hours or less	generally less expensive to fly
3-5	all	generally less expensive to fly

(iii) Zone 3

Passengers	Meeting Length	Conclusions
1	13 hours or less	generally less expensive to fly (use A-36)
2-5	all	generally less expensive to fly

OTHER GENERAL CONCLUSIONS:

1. In general, the lower the median grade of the group flying the least expensive of the planes should be used.
2. The more passengers making the trip, the less it costs to fly.
3. Grade levels are not that important in comparing costs until one uses differing management accountability factors.

III. RESULTS - TABLE LOOK-UPS

If one does not use differing management accountability factors for each grade level, one can construct cost matrices for each of the zones and for each of the planes and for travel by state automobile. Because the number of passengers and the meeting length are the most important of the variables in explaining variation of costs in any one zone, the matrix would look something like this:

COST MATRIX

AREA: ZONE 1

MODE OF TRAVEL: A-36

meeting length (hours)	number of passengers 1	2	3	4	5
2					
5					
8					
13					
24					
32					

(average or estimated (regression) costs for cities in Zone 1, regardless of grade in here)

If one followed this general outline for a table look-up there would be a total of fifteen tables (3 zones x 5 modes of travel). This number could be reduced by inserting the automobile mode into the matrix in some manner (such as printing the flying mode black and the automobile mode red). This would reduce the number of tables to twelve (3 zones x 4 modes of travel).

Another possibility is to construct look-up tables that would not give an estimated cost, but would only illustrate whether or not a given mode of travel was the least expensive to utilize for any given situation. Such a table might look like this:

LEAST EXPENSIVE WAY TO TRAVEL

AREA: ZONE 1

meeting length (hours) \ number of passengers	1	2	3	4	5
2	SC	SC	SC	SC	SC
5	SC	SC	SC	A36	A36
8	SC	SC	BAR	BAR	C340
13	SC	SC	C340	C340	C340
24	SC	SC	C340	C340	C340
35	SC	SC	C340	DUKE	DUKE

where

SC = State Car
A36 = A-36
BAR = Baron 58
C340 = C-340
DUKE = Duke

This would also imply that, for example, if the Duke is the least expensive mode in the matrix, then the C-340, Baron 58, and the A-36 could also be used; since, for the most part, they are less expensive to fly (in that order). The drawback in using this sort of matrix is that sometimes the costs of driving or flying are not that much different. However, this matrix might be supplemented by the cost estimate equation presented in the next section. The obvious advantage in presenting these matrices is that there would only be three of them and, as such, they could be presented on one page. Also, from such matrices one can generally get a feel for any situation by examining those entries near the one being investigated.

IV. RESULTS - ESTIMATION EQUATIONS

Least squares techniques were used to develop estimating equations for driving or flying within each of the zones. Because the median grade level was not that important (with equal management accountability factors) for comparing traveling costs by automobile or airplane only two variables were used to determine the cost equations. These equations are presented by zone with the following variable explanation.

NH = meeting length in hours
NP = number of passengers making trip
CDR = cost of driving
CFL1 = cost of flying the Duke
CFL2 = cost of flying the C-340
CFL3 = cost of flying the Baron 58
CFL4 = cost of flying the A-36

COST ESTIMATION EQUATIONS

ZONE 1

CDR = -116.54 + 9.84NH + 81.27NP (automobile)
CFL1 = 30.12 + 23.26NH + 45.65NP (Duke)
CFL2 = -13.73 + 23.26NH + 45.97NP (C-340)
CFL3 = -34.02 + 23.26NH + 46.11NP (Baron 58)
CFL4 = -83.15 + 23.26NH + 47.31NP (A-36)

ZONE 2

CDR = -81.80 + 9.08NH + 135.54NP
CFL1 = 171.87 + 23.26NH + 50.76NP
CFL2 = 90.99 + 23.26NH + 51.34NP
CFL3 = 53.56 + 23.26NH + 51.60NP
CFL4 = -37.05 + 23.26NH + 53.81NP

ZONE 3

CDR = -49.63 + 9.54NH + 224.20NP
CFL1 = 489.31 + 23.16NH + 69.40NP
CFL2 = 327.84 + 23.16NH + 70.56NP
CFL3 = 253.12 + 23.16NH + 71.08NP
CFL4 = 72.22 + 23.16NH + 75.49NP

Because these equations only estimate the actual costs and because costs rise so rapidly as the meeting lengths get longer and the number of pas-

sengers increase, some of the costs for the smaller values of meeting lengths and passenger numbers make little sense. However, for the sake of comparing the costs of driving and flying these estimates can still be used.

Following are several examples of estimating costs of flying and driving and comparing each.

EXAMPLE 1

5 Hour Meeting in Billings with 3 Passengers -

Billings is in Zone 2 so the set of equations in Zone 2 were used to estimate the costs.

MODE OF TRANSPORTATION	ESTIMATED COST	ACTUAL COST (Grade 14)
CDR (driving)	$ 370.22	$ 371.87
CFL1 (Duke)	440.45	492.72
CFL2 (C-340)	361.31	400.62
CFL3 (Baron 58)	324.66	357.97
CFL4 (A-36)	240.68	259.50

One can readily see that, while the estimate for driving is quite good, those for flying are not as close to actual costs. However, the purpose of the cost equations is to determine whether or not it would be less expensive to fly to Billings under the given set of circumstances, and of course it is, as illustrated by the estimated and actual cost of the trip.

EXAMPLE 2

8 Hour meeting in Forsyth with 4 Passengers -

Forsyth is in Zone 3 so that the third set of equations will be used to estimate costs.

MODE OF TRANSPORTATION	ESTIMATED COST	ACTUAL COST (Grade 17)
CDR	$ 923.49	$ 822.26
CFL1	952.19	870.42
CFL2	795.36	737.89
CFL3	722.72	676.50
CFL4	559.46	539.95

Again, even though some of the estimates appear quite rough one can still use them correctly for comparison.

The estimating equations presented in this section are not intended to be the final or ultimate set of equations. Much more time and research would be needed to develop better fitting equations. However, some general conclusions and inferences might be noted from these equations.

(i) In reducing the number of variables (by creating zones and ignoring grade levels) the poorer the estimating equations become.

(ii) One could use the actual equations for getting at costs. However, this would mean that one would have to supply the user with data tables (pay rates, distances, etc.).

(iii) One could reduce the number of equations in each zone by assuming constant cost differences between aircraft. (This is almost true as one can see from the coefficients of the variables.)

V. OTHER CONSIDERATIONS

Several other possibilities exist in examining the costs of state employee travel.

A. One could draw a sample large enough to make inferences for all of the trips made by state car say for last year, and then compute the cost of flying for the same trip and actually verify what percent of the time, if any, and money could have been saved by flying. This would not be difficult to do and would give one more insight into answering the question, "Should state employees use state aircraft more often?".

B. It is impossible to develop any cost comparisons if one considers all the intangibles in using state aircraft. Also, some of these intangibles are considered the most important reasons for flying (time for instance).

C. In order to develop effective cost estimation equations several considerations would have to be made clear:

(i) If management accountability factors were to be used, it would be necessary to determine at some higher level in state government what values these factors would be in order to apply them consistently throughout the state departments.

(ii) Much more time and money would have to be spent to develop the best equations over all the data available (all grade levels and all hourly meeting lengths).

APPENDIX 1

City	Round Trip Driving Distance	Round Trip Flying Distance
Anaconda	162	110
Baker	852	760
Billings	448	370
Bozeman	190	160
Broadus	784	660
Butte	128	120
Chester	418	276
Chinook	446	402
Circle	770	650
Conrad	284	230
Cut Bank	378	300
Dillon	242	220
Forsyth	602	540
Glasgow	720	600
Glendive	846	720
Great Falls	178	160
Hamilton	324	220
Harlem	496	438
Havre	404	346
Hardin	496	438
Kalispell	460	340
Lewistown	376	270
Libby	608	440
Livingston	242	220
Miles City	692	600
Missoula	230	220
Plentywood	1010	780
Red Lodge	520	346
Sidney	918	780
West Yellowstone	350	288
Wolf Point	818	670

APPENDIX 2

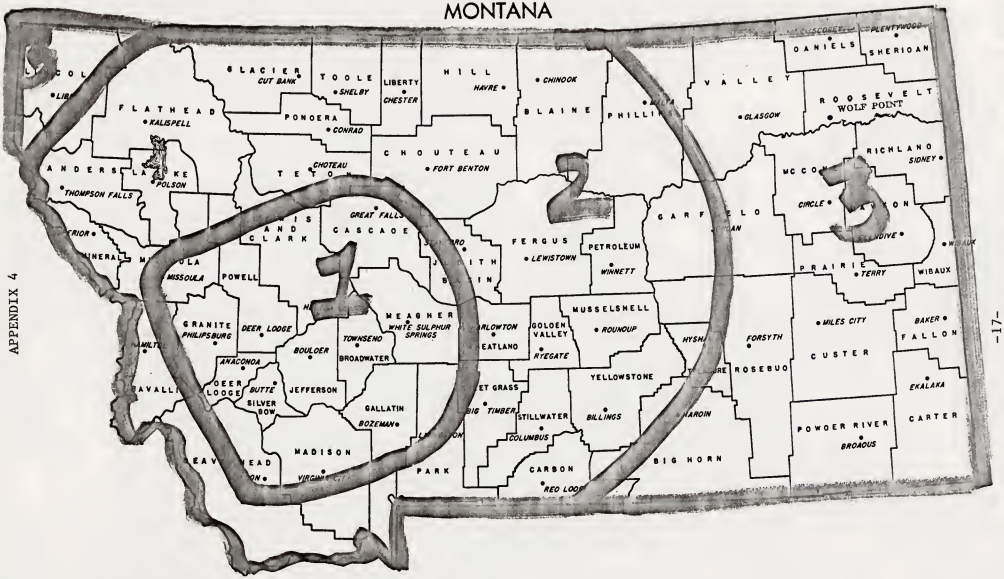
FLYING PER DIEM

City	Meeting Length in Hours					
	2	5	8	13	24	35
Anaconda	0	3	3	29	55	107
Baker	3	8	29	34	77	107
Billings	0	3	3	29	55	107
Bozeman	0	3	3	29	55	107
Broadus	3	3	29	29	77	107
Butte	0	3	3	29	55	107
Chester	0	3	3	29	55	107
Chinook	0	3	3	29	55	107
Circle	3	3	29	29	77	107
Conrad	0	3	3	29	55	107
Cut Bank	0	3	3	29	55	107
Dillon	0	3	3	29	55	107
Forsyth	3	3	26	29	74	107
Glasgow	3	3	26	29	74	107
Glendive	3	8	29	34	77	107
Great Falls	0	3	3	29	55	107
Hamilton	0	3	3	29	55	107
Harlem	0	3	3	29	55	107
Havre	0	3	3	29	55	107
Hardin	0	3	3	29	55	107
Kalispell	0	3	3	29	55	107
Lewistown	0	3	3	29	55	107
Libby	0	3	3	29	55	107
Livingston	0	3	3	29	55	107
Miles City	3	3	26	29	74	107
Missoula	0	3	3	29	55	107
Plentywood	3	8	29	34	77	107
Red Lodge	0	3	3	29	55	107
Sidney	3	8	29	34	77	107
West Yellowstone	0	3	3	29	55	107
Wolf Point	3	3	29	29	77	107

APPENDIX 3

DRIVING PER DIEM

City	Meeting Length in Hours					
	2	5	8	13	24	35
Anaconda	3	8	10	34	62	107
Baker	34	55	60	81	112	156
Billings	26	29	29	55	81	112
Bozeman	3	8	10	34	62	107
Boradus	34	55	55	81	107	138
Butte	3	3	10	29	62	107
Chester	8	29	29	55	81	112
Chinook	26	29	29	55	81	112
Circle	34	55	55	81	107	138
Conrad	3	8	29	34	81	112
Cut Bank	8	29	29	55	81	112
Dillon	3	8	29	34	81	107
Forsyth	29	34	55	60	107	133
Glasgow	34	52	55	78	107	138
Glendive	34	55	55	81	107	138
Great Falls	3	8	10	34	62	107
Hamilton	3	29	29	55	81	112
Harlem	26	29	29	55	81	112
Havre	8	29	29	55	81	112
Hardin	26	29	29	55	81	112
Kalispell	26	29	29	55	81	112
Lewistown	8	29	29	55	81	112
Libby	29	34	55	60	107	133
Livingston	3	8	29	34	81	112
Miles City	34	52	55	78	107	138
Missoula	3	8	29	34	81	107
Plentywood	52	55	60	81	112	159
Red Lodge	29	34	55	60	107	133
Sidney	34	55	60	81	112	156
West Yellowstone	3	29	29	55	81	112
Wolf Point	34	55	55	81	107	138



No. 1052 — County Outline Map
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